Description of sensory preservation in children and adolescents with incomplete spinal cord injury

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Background/objective: This cross-sectional, multicenter cohort study describes patterns of preserved sensation in persons with American Spinal Injury Association (ASIA) Impairment Scale (AIS) B (sensory incomplete, or SI) and AIS C/D (motor incomplete, or MI).

Methods: A total of 93 subjects with incomplete spinal injuries (58 with tetraplegia and 35 with paraplegia) were included for analysis. Sensation was based on the International Standards for Neurological Classification of SCI (ISNCSCI).

Results: In the 44 subjects with AIS B (SI), some light touch (LT) was present in 35% of dermatomes below the neurological level and pin prick (PP) in 8%. In contrast, in the 49 subjects with AIS C/D (MI), LT was present in 77% of dermatomes and PP in 27%. AIS C/D (MI) subjects with tetraplegia had more dermatomes with preserved sensation than those with paraplegia. When reviewing areas at highest risk for pressure sores, only 4 of 22 (19%) of subjects with AIS B (SI)/tetraplegia had any preserved LT or PP sensation in the periscapular region (dermatomes T1–T6). In the buttocks region (S3 and S4–S5), sensation was preserved in fewer than 50% of patients with either tetraplegia or paraplegia.

Conclusions: (1) Sensory sparing below the neurologic injury was found to be surprisingly sparse in patients classified as AIS B (SI) (35% LT and 8% PP). Sparing was considerably better in patients who were AIS C/D (MI) (77% LT and 27% PP). (2) Preserved sensation in the periscapular region was very low in subjects with tetraplegia (19%) and was also low in the buttocks, with fewer than half of those classified as AIS B (SI) with either tetraplegia or paraplegia reporting sensation.

Keywords: Sensory preservation, Incomplete spinal cord injury, Light touch, Pin prick

Introduction

The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) uses the American Spinal Injury Association (ASIA) Impairment Scale (AIS) to categorize severity of spinal cord injury (SCI) into four groups: AIS A (complete); AIS B (sensory incomplete) AIS C: sensory and gravity eliminated motor incomplete (MI); and AIS D: sensory and against gravity motor complete (reference: ASIA. Manual for International Standards for Neurological Classification of Spinal Cord Injury. ASIA: Chicago 2003). Approximately 50% of adults with SCI are classified as having an incomplete injury, with an AIS grade B (SI).[1] Approximately 33% of children younger than 8 years old and 50% of adolescents with SCI are classified as having an incomplete injury, with an AIS grade B.[2] Conversion from a complete injury to an incomplete injury can occur in the acute and subacute phases of injury. Fawcett *et al*. found that the conversion rate of complete AIS A to B, C, or D is approximately 10%.[3] Burns *et al*.[4] reported that 6.7% of injuries convert from AIS A to B within 72 hours following initial injury. Kirshblum *et al*. reported a late (greater than 30 days) conversion rate of 2.1% from AIS A to B by 1-year post-injury using model systems data.[5] The percentage of patients with tetraplegia and paraplegia converting to AIS B is 6.6 and 1.6%, respectively. Despite these reports of conversion rate from AIS A to B, the clinical significance of a complete injury converting to a SI injury has not been fully explored.

In children and youth classified as AIS B, the typical pattern or patterns of sensory preservation below the

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neurologic level of injury have not been described, nor have the patterns of sensory sparing been described in youths with AIS C/D (MI). Clinicians, particularly those who do not routinely work with children and adolescents with SCI, may mistakenly assume that patients who have been classified as AIS B, C, D, or converted to SI may be at lower risk for pressure sores and may not need the standard education regarding risks related to sensory loss after SCI. Knowledge of the patterns of sensory return would inform practice with respect to prevention of pressure sores and risks associated with seating and positioning.

The purpose of this paper is to describe the patterns of preserved sensation in a cohort of youths classified as having AIS B (SI) and to compare them to patterns of preserved sensation in those classified as having AIS C/D (MI).

Methods

This study is part of a larger multicenter effort to determine the reliability of the ISNCSCI in children.[6–8] The sensory, motor, and anorectal examination techniques and the classification methodology of the ISNCSCI have been previously described.[8] The sensory examination involves testing of 28 dermatomes on the right and left side of the body for sensitivity to pin prick (PP) and light touch (LT). The motor examination is completed through the testing of 10 muscles bilaterally. The strength of each muscle is graded on an ordinal scale between 0 (complete paralysis) to 5 (normal active movement, full range of motion against full resistance). These scores are summed across myotomes and sides of the body to generate a single total motor score (TM). There has been a recommendation to separate the upper extremity motor and lower extremity motor scores. The anorectal examination involves the evaluation of sensation and contraction of the external anal sphincter. Seven raters who were formally trained in the evaluation[9] and classification[10] methods of the ISNCSCI performed all evaluations. All participants and their parents provided written informed assent and consent, respectively, and HIPAA forms were approved by the Institutional Review Board. Only subjects with incomplete injuries as defined by the ISNCSCI[11] as having sacral sparing were included for analysis.

Sample

A total of 93 subjects with incomplete injuries were included for analysis (Table 1). The average age at time of examination was 15.1 ± 4.1 years, with 19 subjects aged 6–11 years, 26 subjects aged 12–15 years, and 28 subjects aged 16-21 years old. The average time since injury was 5.8 ± 4.8 years, with 14 injured less than 1 year prior and 79 injured greater than 1 year prior. The average age at the time of injury was 9.6 ± 6.4 years, with 35, 15, 22, and 21 patients being 0–5, 6–11, 12–15, and 16–21 years old, respectively. Of the 93, 58 had tetraplegia and 35 had paraplegia. There were 44 subjects with AIS B, 28 subjects with AIS C, and 21 subjects with AIS D injuries.

Table 1 Demographics of sample population

	Total
Total number of subjects (*n*)	93
Age at time of evaluation (years)	
6–11	19
12–15	26
16–21	28
Age at time of injury (years)	
Birth–5	35
6–11	15
12–15	22
16–21	21
Type of injury	
Tetraplegia	58
Paraplegia	35
AIS	
AIS B	44
AIS C	28
AIS D	21
Average age at time of evaluation	15.1 ± 4.1 years
Average age at time of injury	9.6 ± 6.4 years
Average time since injury	5.8 ± 4.8 years

Data analysis

For analysis, subjects were grouped by the AIS as follows: SI (AIS B) and MI (AIS C and D). Subjects were also grouped by type of injury (tetraplegia versus paraplegia). All data were de-identified, exported to a spread sheet, and analyzed using descriptive statistics.

Initially, LT and PP were analyzed. Sensation was tested and scored as a '0' (absent sensation), '1' (impaired sensation), or '2' (intact sensation). The number of dermatomes with some sensation (score of 1 or 2) was calculated by dividing the number of dermatomes below the neurological level with any sensation by the number of available dermatomes below the neurological level.

Results

Sensation in dermatomes below the neurologic level

In the 44 subjects with AIS B (SI), some LT was present in 35% of dermatomes and some PP in 8%. In contrast, in the 49 subjects with AIS C/D (MI), some LT was present in 77% of dermatomes and PP in 27% (Table 2).

Further subanalysis of subjects with AIS B (SI) showed little difference between tetraplegia and paraplegia, however. Subjects with MI/tetraplegia had a greater

Table 2 LT and PP

	AIS group	
	B ($n = 44$)	C/D ($n = 49$)
LT% not zero/available dermatomes	35	77
PP% not zero/available dermatomes	8	27

percentage of dermatomes with preserved sensation than those with MI/paraplegia (Table 3).

Sensation in clinically significant regions

In the periscapular region (dermatomes T1–T6), only 4 of the 22 subjects (19%) with AIS B (SI)/tetraplegia had any preserved LT or PP sensation. In contrast, of the 36 subjects with AIS C/D (MI)/tetraplegia, 20 (55%) had preserved LT or PP.

In the perianal region, patients with tetraplegia and paraplegia and AIS B (SI) had less than 50% of any sensation in the buttocks (S3 and S4/S5 dermatomes). In contrast, patients with AIS C/D (MI) had a much higher percentage of preserved sensation, approaching 80% in those with tetraplegia and 50–70% in those with paraplegia (Table 4).

Table 3 Tetraplegia versus paraplegia

	AIS group			
	Tetra		Para	
	B ($n = 22$)	C/D ($n = 36$)	B ($n = 22$)	C/D ($n = 13$)
LT% not zero/ available dermatomes	32	81	37	66
PP% not zero/ available dermatomes	4	30	11	21

Table 4 Average percent of individual level 'any sensation' preserved (grouped according to tetraplegia or paraplegia)

	SI = B		MI = C/D	
	Tetra ($n = 22$) (%)	Para ($n = 22$) (%)	Tetra ($n = 36$) (%)	Para ($n = 13$) (%)
Any L4 sensation	14	36	78	62
Any L5 sensation	18	36	83	62
Any S1 sensation	27	36	83	54
Any S2 sensation	27	36	81	69
Any S3 sensation	41	32	81	54
Any S4–S5 dermatome sensation	50	41	81	69
Any anal sensation	100	95	94	100
Any anal contraction	0	0	39	69

Discussion

This study showed a low percentage of sensation in dermatomes in patients classified by the AIS as sensory incomplete (B), with LT present in 35% of dermatomes and PP in only 8%. This was similar whether the patients had tetraplegia or paraplegia. Also surprising was the low percentage of sensation in clinically important areas for preventing pressure sores. In the periscapular region (dermatomes T1–T6), only 4 of 22 (19%) of the subjects with AIS B (SI)/tetraplegia had any preserved LT or PP sensation. Even in subjects with AIS C/D (MI)/tetraplegia, only 20 of 36 (55%) had preserved LT or PP. This information is extremely important for clinicians treating children and adolescents with SCI, as there is a tendency to assume that if the patient has an incomplete injury, they may not need the same pressure sore precautions as a patient with a complete injury. This is because the AIS B designation can be given for just internal deep anal vault pressure without sensory preservation beyond the level of injury. Subjects with AIS B can have little or no preserved sensation in the skin area and, therefore, their sensory incompleteness may not provide added protection against development of pressure sores. Thirty-eight percent of subjects were AIS B because of deep internal anal vault pressure only.

In all the analyses, the subjects with MI had more preserved sensation than those with SI. This may be explained by the anatomic fact that the lateral cortical spinal tract (LCST (motor)) lies adjacent to the lateral spinothalamic tract (LSTT (PP sensation)). An injury preserving the LCST should also preserve more of the LSTT; likewise, a more severe injury, completely destroying the motor tracts (LCST), would also likely destroy more of the sensory tract.

In the S3 and S4–S5 regions, only 45% of those with AIS B (SI) and 78% with AIS C/D (MI) reported some sensation. In contrast, in these same subjects, deep internal anal sensation approached 100% in both the AIS B (SI) and AIS C/D (MI) patients. Possible explanations are that some of the patients who report deep internal anal sensation may in fact have sensation being carried by a different tract, such as the autonomic nervous system, or that preserved sensory function at the distal most segment may manifest itself more frequently by the anorectal exam compared to PP and LT at S3 and S4–S5. Another explanation can be the present of a high percent of false positives on the internal exam as has been suggested by Vogel *et al.*[6] and Wietek *et al.*[12]

In a study of predicting independent ambulation from S4/5 PP and LT and anal sensation and contraction, van Middendorp *et al*.[13] also questioned the validity of anal sensation to determine completeness versus incompleteness of a SCI.

Conclusion

Sensory sparing below the neurologic injury was found to be sparse in patients with AIS B (SI) (35% LT and 8% PP). Sparing was considerably better in patients who were AIS C/D (MI) (77% LT and 27% PP). In subjects with tetraplegia and AIS B (SI), there was low preserved sensation in the clinically important periscapular and buttock region, with fewer than half reporting any LT or PP sensation.

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